US010434558B2

(12) **United States Patent**
Sines

(10) **Patent No.: US 10,434,558 B2**
(45) **Date of Patent: Oct. 8, 2019**

(54) **TOOLPACK FOR MANUFACTURING CONTAINERS**

(71) Applicant: **CanForming Systems, LLC**, Broomfield, CO (US)

(72) Inventor: **James A. Sines**, Broomfield, CO (US)

(73) Assignee: **CANFORMING SYSTEMS, LLC**, Broomfield, CO (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/474,031**

(22) Filed: **Mar. 30, 2017**

(65) **Prior Publication Data**

US 2018/0281045 A1 Oct. 4, 2018

(51) **Int. Cl.**
B21D 22/28 (2006.01)
B21D 22/20 (2006.01)
B21D 51/26 (2006.01)

(52) **U.S. Cl.**
CPC ***B21D 22/286*** (2013.01); ***B21D 22/20*** (2013.01); *B21D 51/26* (2013.01)

(58) **Field of Classification Search**
CPC B21D 51/26; B21D 22/28; B21D 22/286; B21D 22/20; B21D 22/30
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,402,591	A	9/1968	Maeder	
3,656,335	A	4/1972	Kaminski	
3,771,344	A	11/1973	Wright	
3,812,696	A	5/1974	Kneusel et al.	
4,065,951	A	1/1978	Lyu	
4,151,927	A	5/1979	Cvacho et al.	
4,223,544	A	9/1980	Main	
4,262,512	A	4/1981	Maeder	
4,324,124	A *	4/1982	Maeder	B21D 22/28 72/345
4,373,368	A	2/1983	Heijting	
4,554,815	A *	11/1985	Weishalla	B21D 22/28 72/349
4,930,330	A	6/1990	Weishalla	
5,020,350	A	6/1991	Knepp et al.	

(Continued)

OTHER PUBLICATIONS

Patent Cooperation Treaty International Search Report and Written Opinion for PCT 2018/US2018/023866, dated May 31, 2018, 7 pgs.

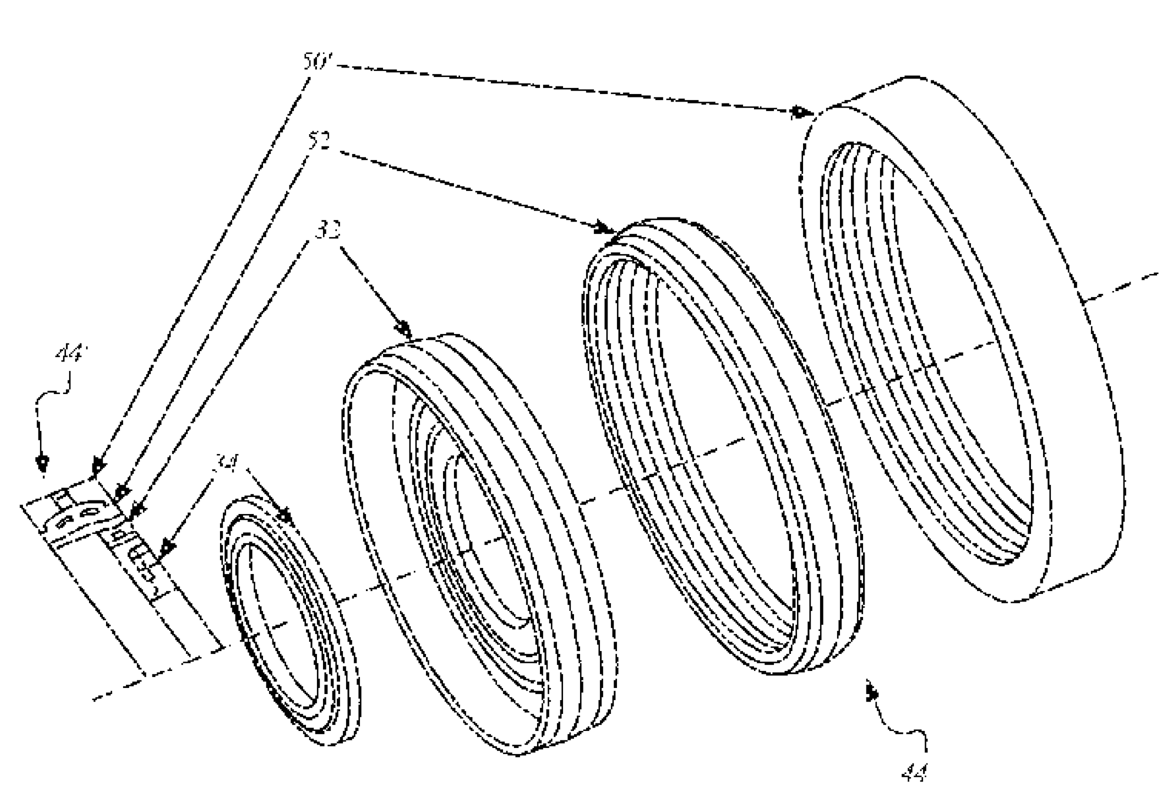
(Continued)

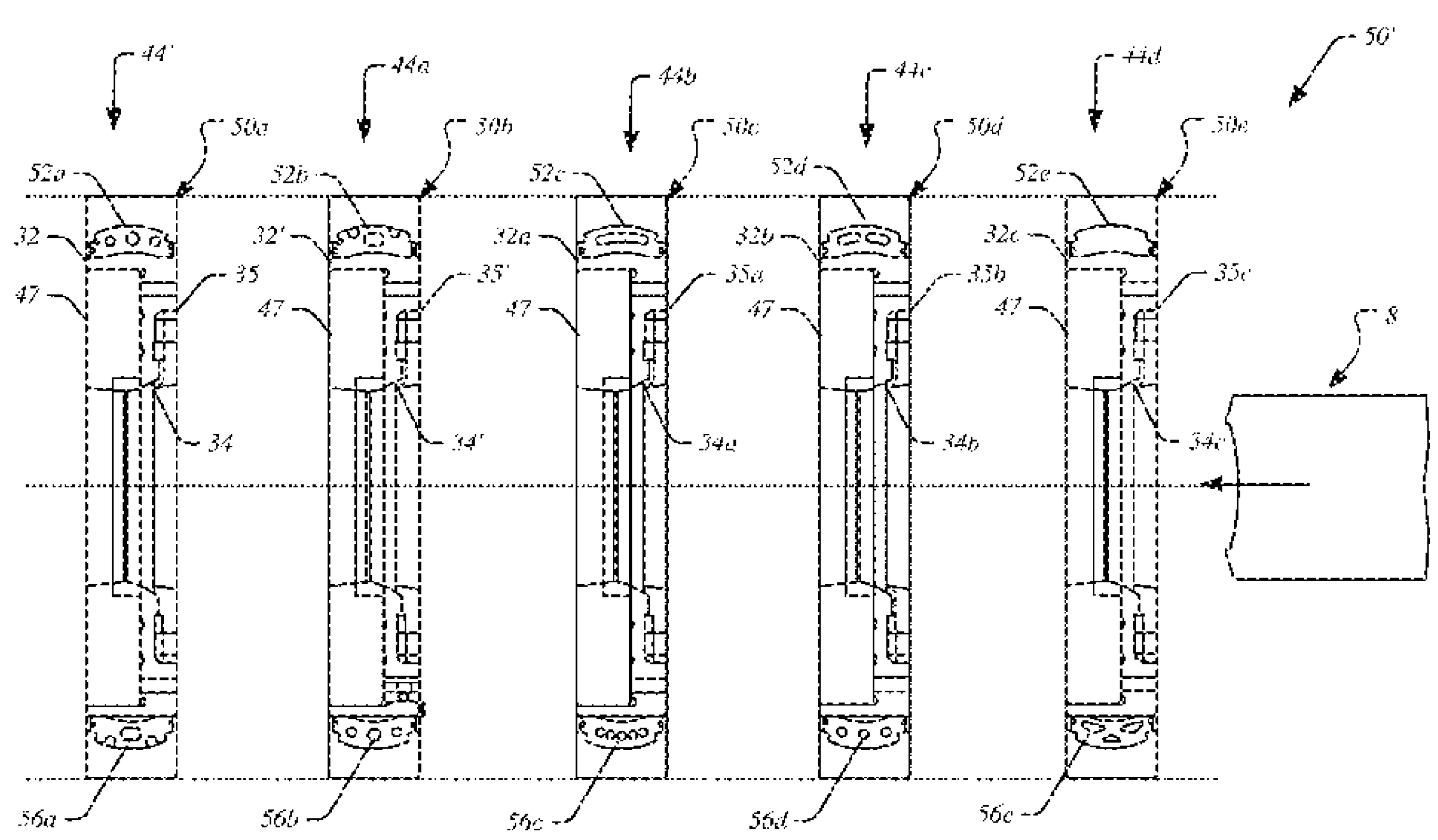
Primary Examiner — Pradeep C Battula
(74) *Attorney, Agent, or Firm* — Pepper Hamilton LLP

(57) **ABSTRACT**

A precision high cyclic rate metal forming toolpack is disclosed for ironing processes used to produce can or other bodies and preforms of ultra-high precision. An example of the toolpack provides improved centering, dampening and force attenuation response. In an example, the toolpack may be implemented with integrated feedback communication and sensoring. An example of the toolpack also provides unified coolant distribution, including enhanced locational intelligence of infinitely variable tooling positions. An example of the toolpack also provides improved axial and longitudinal articulation for improved tool tracking and floatation. The toolpack may enable improved product quality, throughput, manufacturing efficiency, reduced costs, and reduced labor.

20 Claims, 8 Drawing Sheets





(56) **References Cited**

U.S. PATENT DOCUMENTS

5,056,350	A		10/1991	Moen et al.	
5,555,761	A	*	9/1996	Lavy	B21D 22/28 72/347
5,692,409	A	*	12/1997	Cheers	B21D 22/28 72/349
6,598,451	B2	*	7/2003	Blue	B21D 22/28 72/342.3
7,107,811	B2	*	9/2006	Zauhar	B21D 22/21 72/349
7,526,938	B2		5/2009	Dunwoody et al.	
7,805,970	B2		10/2010	Woulds	
9,079,238	B2		7/2015	Crabtree	
9,192,976	B2	*	11/2015	Yannone	B21D 22/20
2003/0084700	A1		5/2003	Blue	
2006/0086170	A1		4/2006	Zauhar	
2018/0133770	A1		5/2018	Swedberg	

OTHER PUBLICATIONS

Screenshot of website: https://www.pawlingep.com showing Custom Rubber and Plastic Products Engineered to Meet your Exact Specifications, known by inventor to be publicly available at least as early as Nov. 2017, 6 pgs.

Screenshot of website: http://www.tekscan.com showing embedded sensors, known by inventor to be publicly available at least as early as Mar. 2017, 5 pages.

"Tekscan I-Scan Product Selection Guide", known by inventor to be publicly available at least as early as Jul. 2018, 28 pages.

Seal Master Corporation, "Seal Master Engineered Inflatable Seats", known by inventor to be publicly available at least as early as Jul. 2018, 8 pages.

* cited by examiner

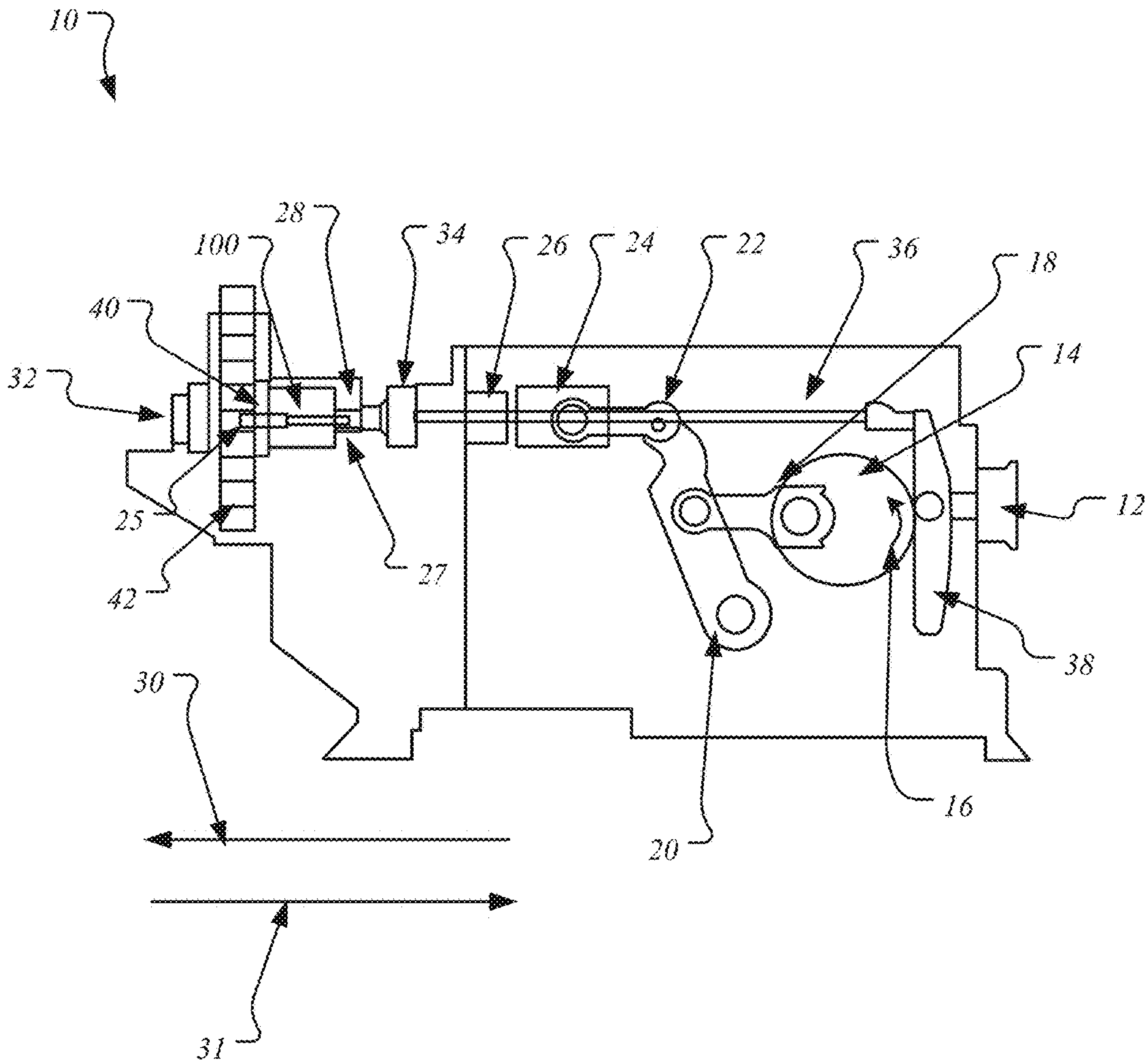


FIG. 1

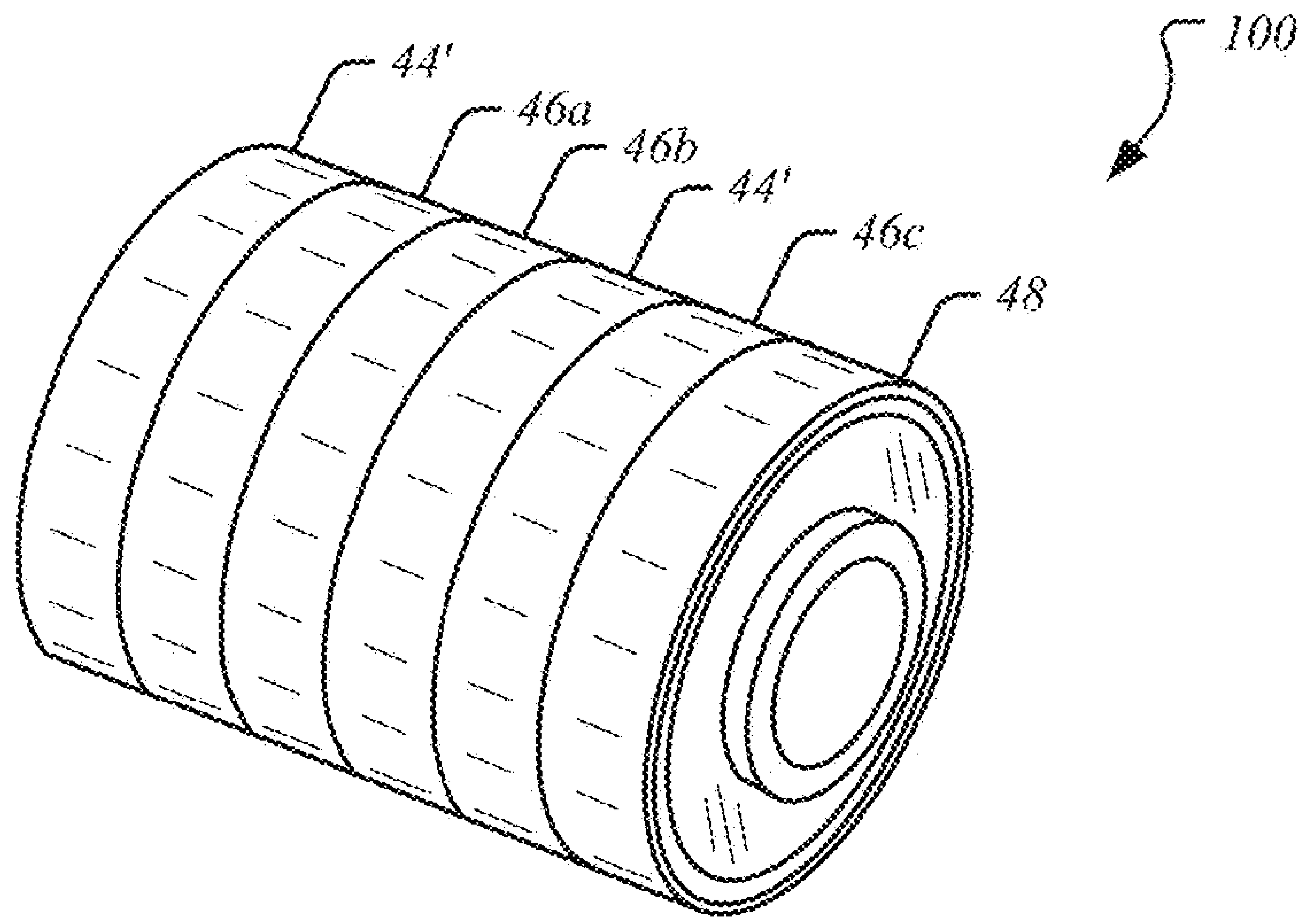


FIG. 2A

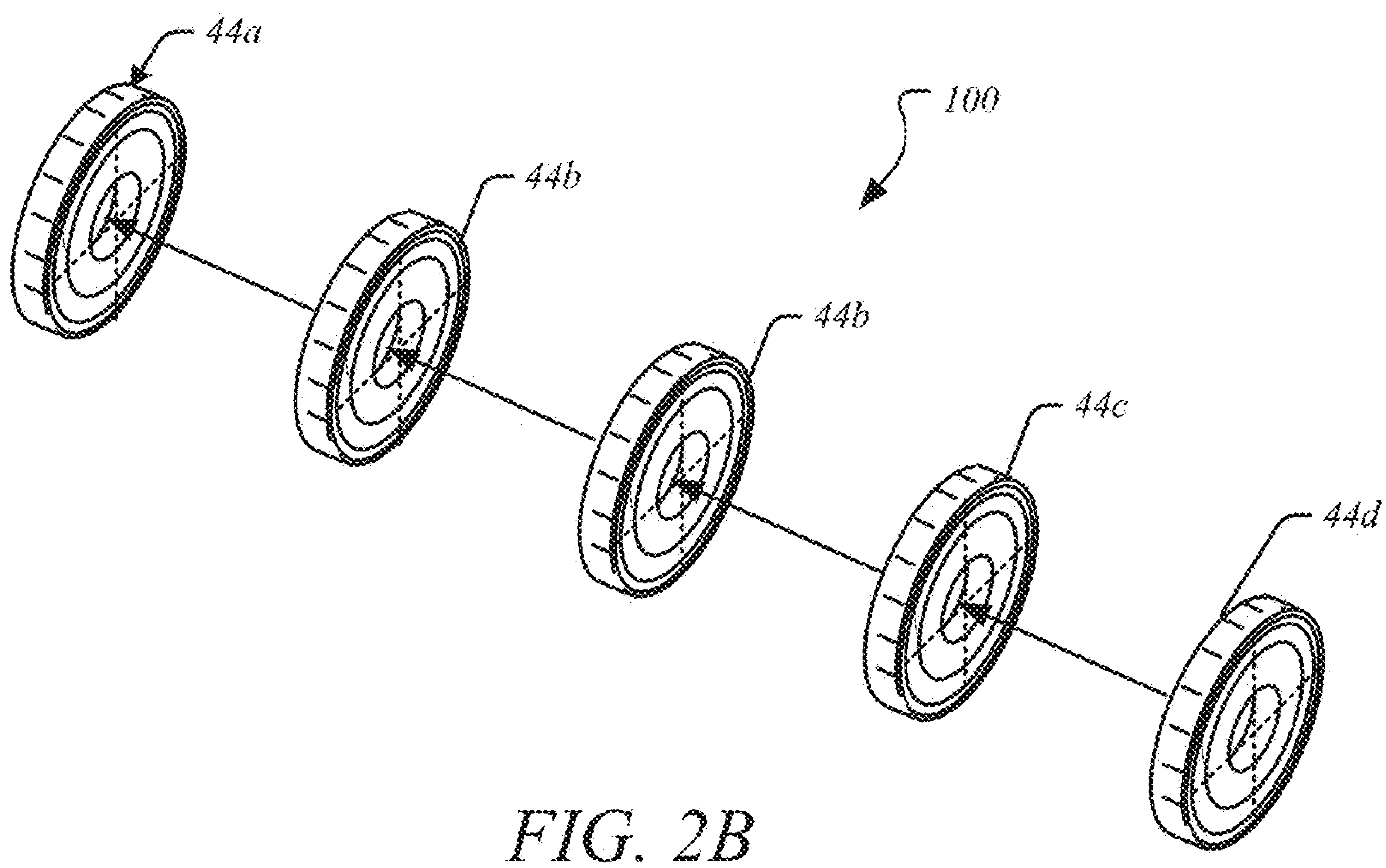


FIG. 2B

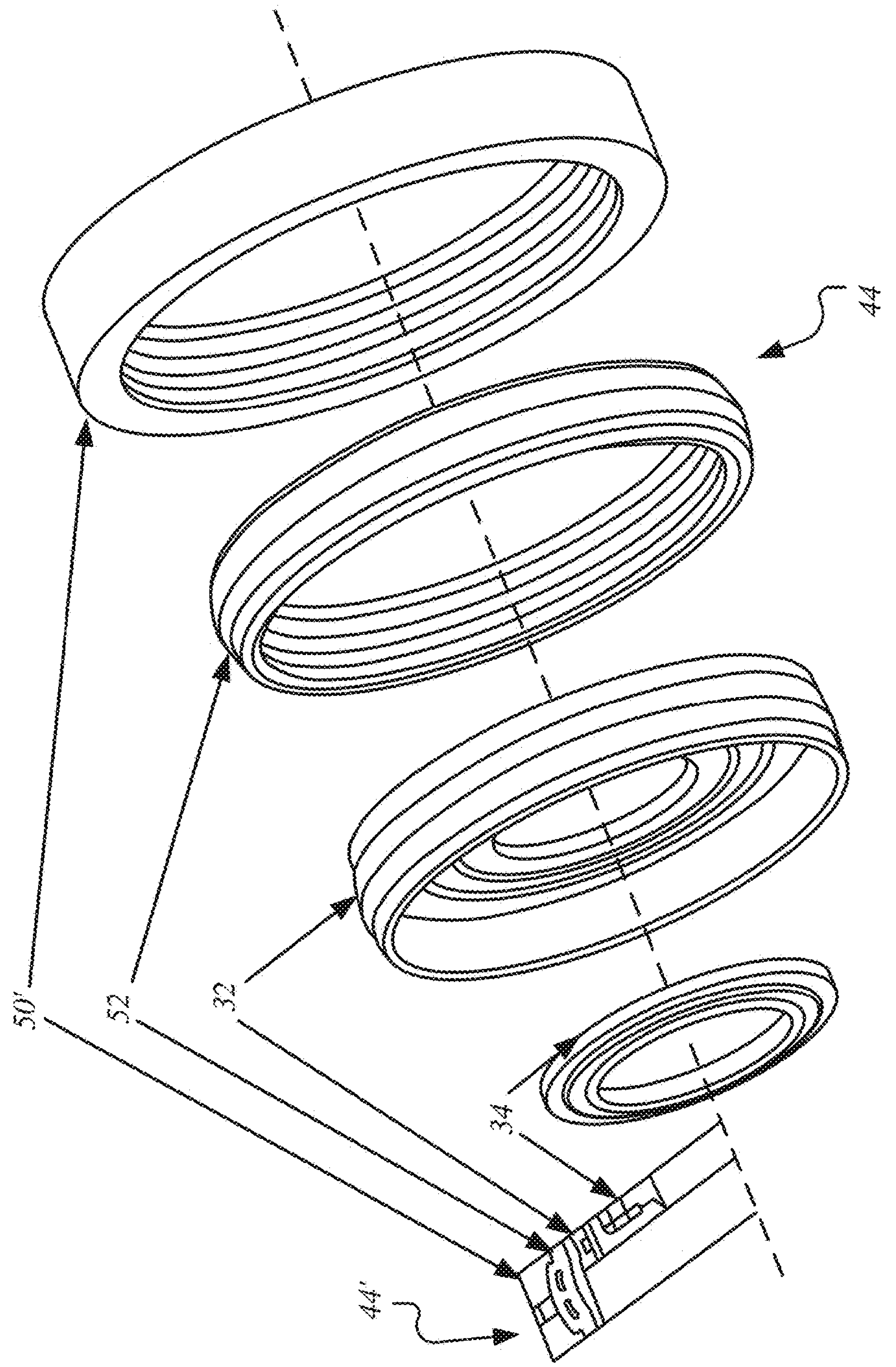
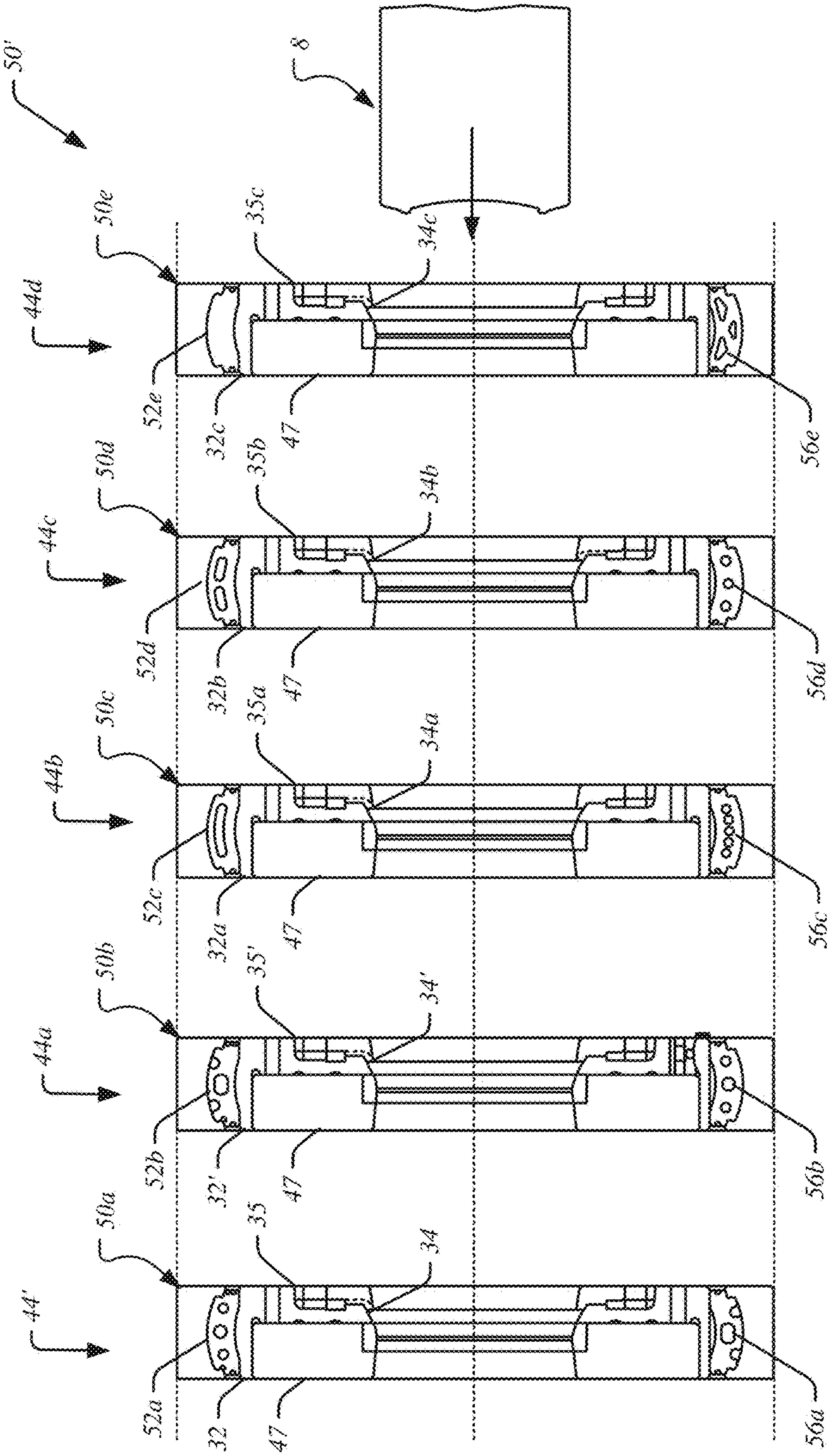


FIG. 3



50'
8
50e
44d
35c
34c
52e
32c
47
56e
50d
44c
35b
34b
52d
32b
56d
50c
44b
35a
34a
52c
32a
56c
50b
44a
35'
34'
52b
32'
56b
50a
44'
35
34
52a
32
56a

FIG. 4

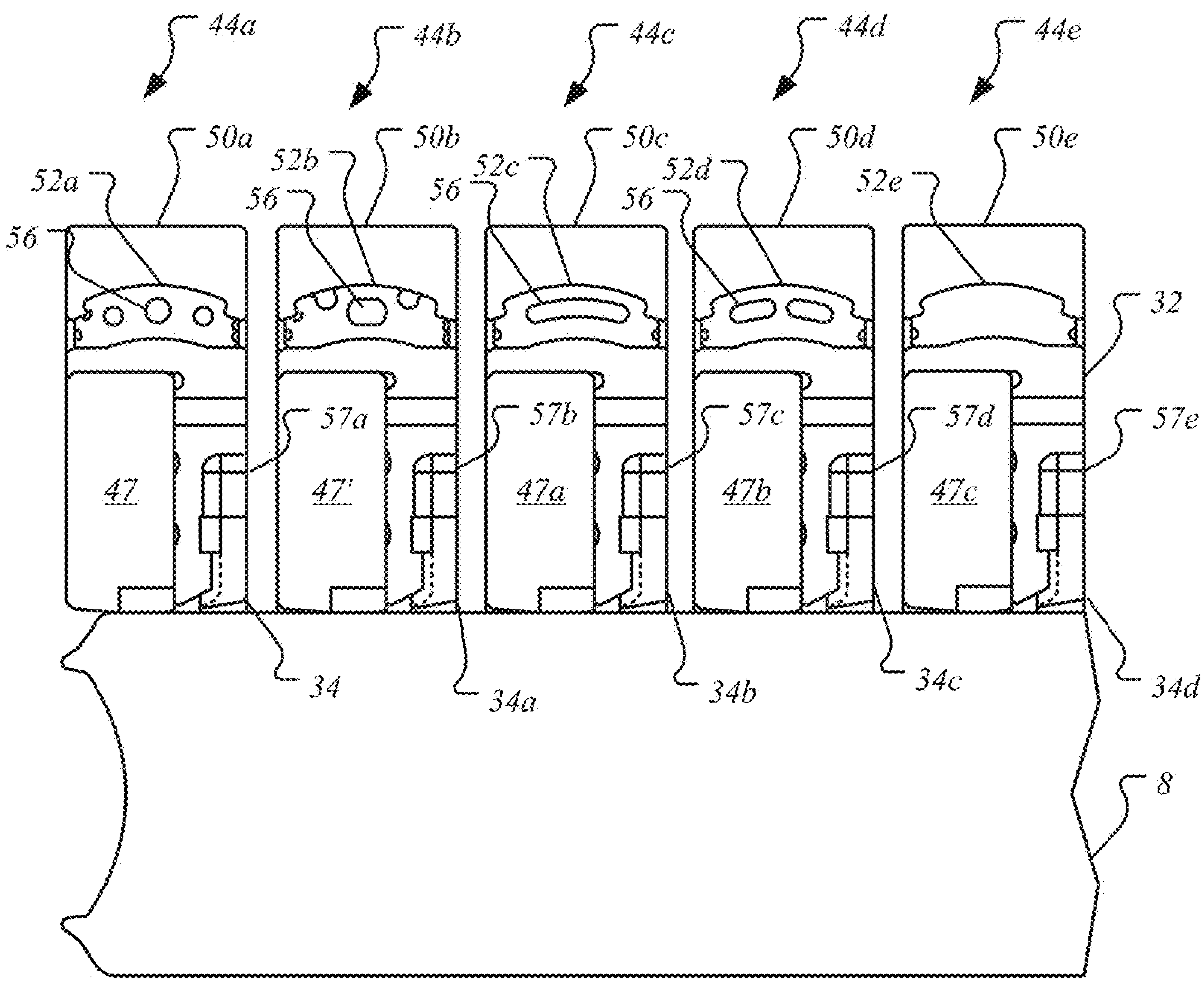

44a
44b
44c
44d
44e
50a
50b
50c
50d
50e
52a
52b
52c
52d
52e
56
56
56
56
32
57a
57b
57c
57d
57e
47
47'
47a
47b
47c
34
34a
34b
34c
34d
8

FIG. 5

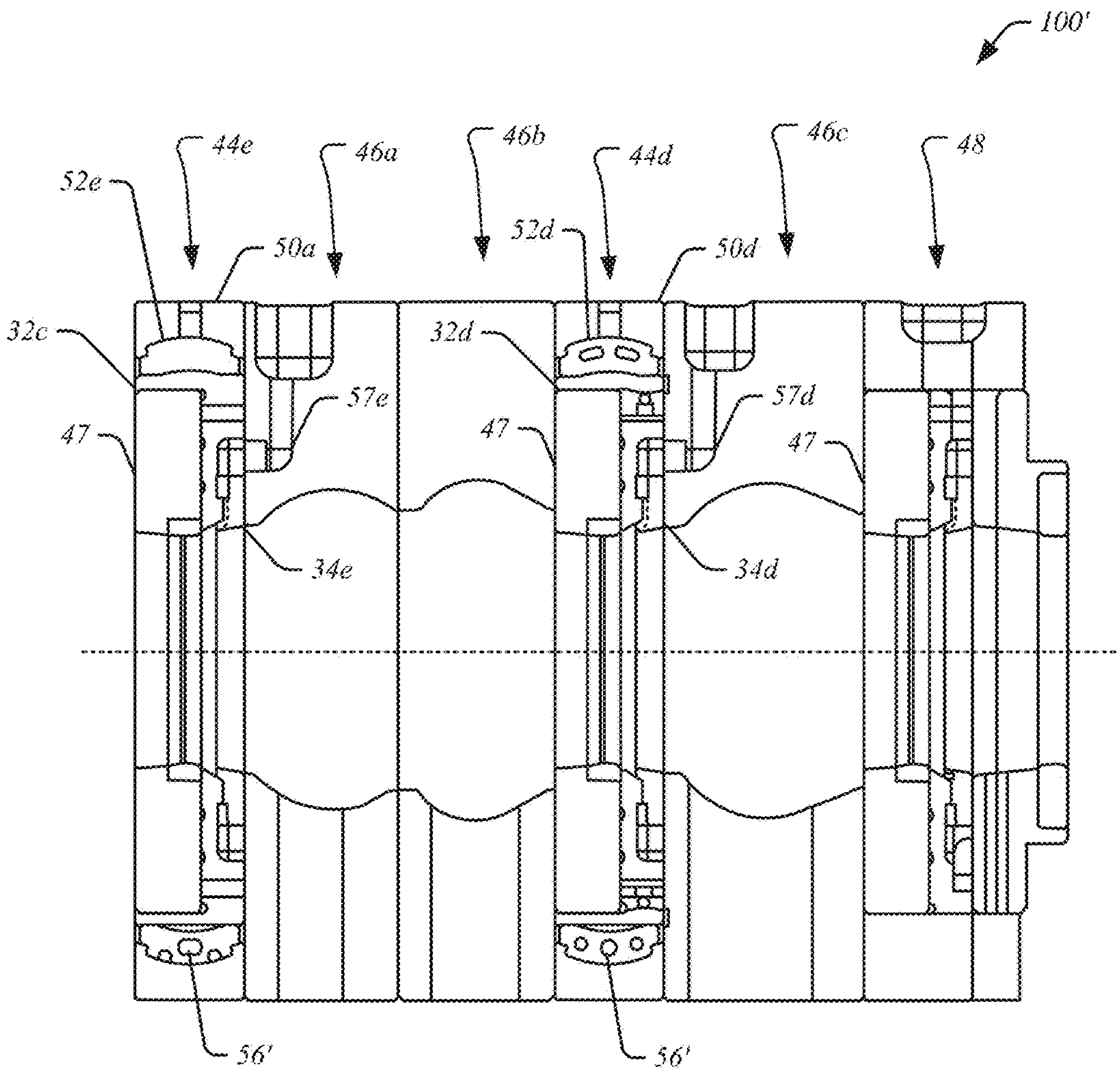

100'
44e
46a
46b
44d
46c
48
52e
50a
52d
50d
32c
32d
57e
57d
47
47
47
34e
34d
56'
56'

FIG. 6

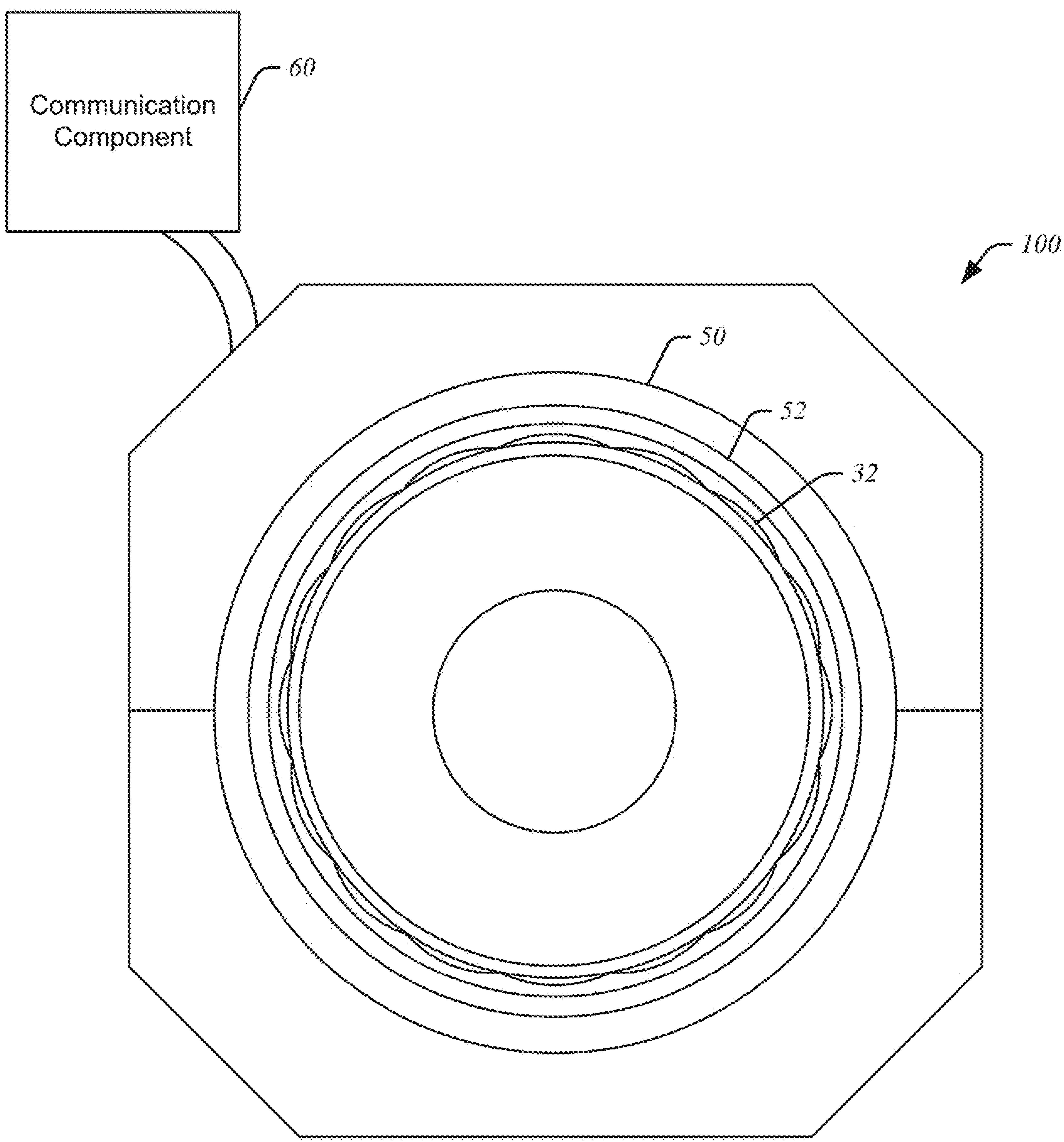


FIG. 7

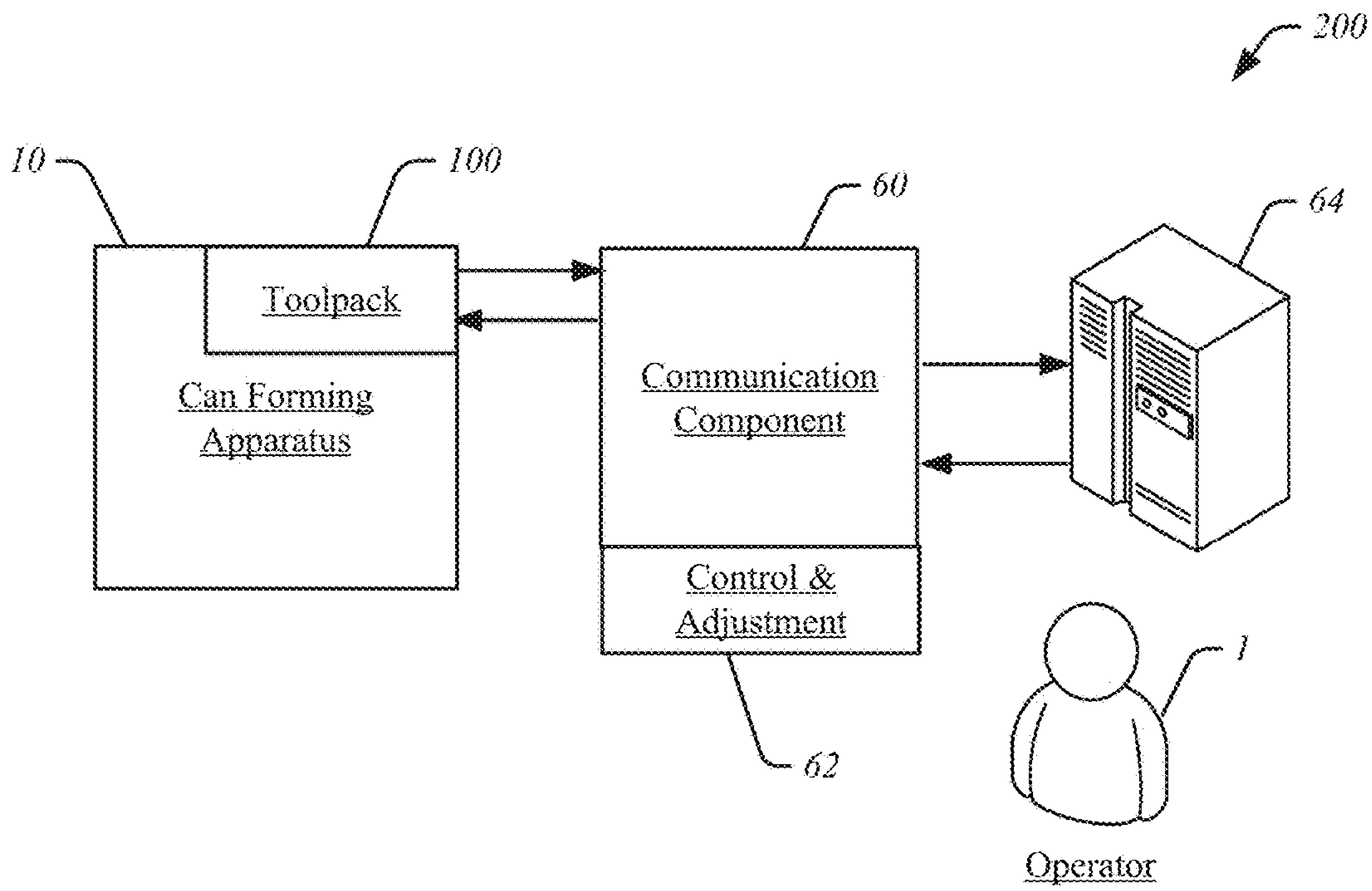

200
10
100
Toolpack
Can Forming Apparatus
60
Communication Component
Control & Adjustment
62
64
1
Operator

FIG. 8

TOOLPACK FOR MANUFACTURING CONTAINERS

BACKGROUND

Metal forming toolpacks are utilized in the ironing apparatus for manufacture and form of metallic can bodies or cylindrical metal bodies and preforms. The metal forming toolpack is commonly constructed of various modules utilized to control the tooling arrangements to produce beverage or food containers integral within the metal forming apparatus of the 'draw(n) and iron' press or 'wall ironer'. The toolpack may include multiple modules which house and integrate the ironing tooling(s) to iron and form the metal thickness of specific geometrically shaped metallic bodies.

Existing toolpacks are limited by configuration and use of mechanical springs or Urethane type spring replacements in fixed radial locations. The limited locational action provides a fixed directional force rate which has no adjustability, nor any discernible communication with the process. Different spring rates are only changed with significant machine down time, mechanical exchanges of spring elements through operator intervention, and significant guess work by skilled analysis. These dampening limitations cause significant degradation of product quality, resulting in lower production speed and efficiency

The Global unit production of aluminum and/or steel beverage containers and bottles is approximately 200 billion units per year. More than 90 billion units are produced in the United States each year. The speed and accuracy at which these billions of metallic containers are produced with such high volumes in complex manufacturing systems, requires the utmost accuracy and manageability of total product population variation.

Manufacturers control the container weight to the milligram and the measurement of the container walls are held within microns. This is simple if making only a single unit, but much more difficult for manufacturing billions. Approximately 400 units are produced every minute on a single apparatus. Factories are typically using over 8 to 10 of these metal forming machines in a line. As such, the entire production line speed often exceeds 2,000 cans per minute. Manufacturing billions of units thus requires extremely high precision and control to ensure that the least amount of material is being utilized, with lowest variations in wall thicknesses. Any variation is multiplied by millions of units rapidly multiplied material misuse. It is important not to make mistakes or mismanage any variation rapidly due to high speed to maintain a consistent and competitive end unit cost.

Those skilled in the art of producing billions of such units understand weight control and management of variance across 200 billion units is an ideal aspect of conserving required materials and optimized production facility efficiency that drive most competitive unit cost basis. Therefore, the interaction of the toolpack and ironing process variance dictate the material weight distribution and is critical to ideal process management outcomes over billions of units. The lack of external attenuation control or adjustment in current production systems, and a limited capability to optimize ironing process variance, negatively impacts speed of production and quality of the product being produced.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a high-level perspective illustration of a metal forming apparatus **1** implementing an example toolpack disclosed herein.

FIG. **2**A is a perspective view of an example toolpack disclosed herein.

FIG. **2**B is an exploded perspective view of the example toolpack shown in FIG. **2**A.

FIG. **3** is an exploded perspective view of one of the toolpack modules.

FIG. **4** are cross-sectional views of various modules of the example toolpack. One or more of these may be implemented in a toolpack.

FIG. **5** are detailed cross-sectional views of an upper portion of the various modules shown in FIG. **4**.

FIG. **6** is a detailed cross-sectional view of typical arrangement of the modules of the example toolpack.

FIG. **7** is an end view of one of the modules of the example toolpack.

FIG. **8** is a high-level block diagram illustrating communication and feedback which may be implemented for the example toolpack.

DETAILED DESCRIPTION

The toolpack and systems and methods described herein greatly improve the ability to manage and control can weight, can wall variation, material utilization, tooling wear rates, improve machine efficiency and therefore manage production performance at the lowest achievable cost basis. The limitation of manufacturing process ironing control variables of dampening speed, action, adjustment and control is directly improved through these enclosed novel embodiments of the invention.

An example high cyclic rate precision metal forming toolpack is disclosed as it may be implemented for the ironing process to form can bodies or other cylindrical bodies and preforms at high rates of speed with minimal variance. The example toolpack improves dampening and force attenuation of tooling control through an integral and contiguous biasing medium structure which is externally excited and communicated. The example toolpack results in a reduction of variance in produced container wall thicknesses. The example toolpack also facilitates improved production speed, product quality, reduced tooling wear, resulting in an improved can weight control, reduced wall variation, improved coolant distribution, coolant impingement, and coolant tracking.

The example toolpack can be readily implemented into existing production apparatus such that both skilled technicians, and non-experienced operators are better enabled to operate the complex ironing processes. In an example, the toolpack enables critical process optimization through adjustability without having to shut down the equipment that would otherwise result in a loss of production volume and profit. An average loss of profit near $85 per minute or every 2,000 cans made, quickly focuses losses resulting from any downtime. These unique aspects help to vastly improve production system management control, production throughput, efficiency and provide novel automation of existing ironing processes. The average efficiency of existing production averages near 85% for common art. With the improvement discussed herein, efficiency of 90% or greater can be achieved.

Automation of these manufacturing systems reduces labor requirements of the utilized machinery work cells and this reduces overall manning requirements of production. The financial savings of labor while increasing production efficiency at a lower unit cost basis is one of the claimed embodiments of this invention.

Before continuing, it is noted that as used herein, the terms "includes" and "including" mean, but is not limited to, "includes" or "including" and "includes at least" or "including at least." The term "based on" means "based on" and "based at least in part on." The terms "can" and "container" are used interchangeably herein to refer to the product being formed. The term "tool" or "die" may be used interchangeably herein to refer to the ironing tooling and/or ironing die. The term "drawn" or "ironed" may be used interchangeably herein to refer to the refer to the process of drawing and ironing of metallic bodies.

It should be understood that the drawings are not necessarily to scale, and various dimensions may be altered. In certain instances, details that are not necessary for an understanding of the invention or that render other details difficult to perceive may have been omitted. It should be understood, of course, that the invention is not necessarily limited to entirety of the particular embodiments illustrated herein.

FIG. **1** is a high-level perspective illustration of an example metal forming apparatus **10** implementing an example toolpack **100** disclosed herein. The example apparatus **10** may be operated to produce light-weight containers, including food or beverage containers and bottle preforms, e.g 'Bodymaker', 'Wall-ironer' or 'Canformer'.

The process of the can body formation begins by the formation of a cup article in a separate machine, called a 'cupping press'. First, a circular "blank" is cut out of a flat sheet of metal. The disc-shape is blanked and fed through the tooling of a cupping press. The blank is "drawn" or pulled through such tooling into the shape of a "cup". The cup article is then transferred to the apparatus **10** to feed the can body formation process of 'draw and iron' (D&I).

In an example, the apparatus **10** includes a continuous motion flywheel and clutch brake assembly connected directly to a crankshaft **14**. Operation of the crankshaft is one revolution results in a single stroke. The cam on the crankshaft **14** follows a motion controlled force by air-bag **12** onto a clamping redraw carriage **34** to control the cup article to be formed into the container, Rotation of the crankshaft **14** is typically counter clockwise as noted by direction of arrow **16**. The mechanism linkage operates via primary connecting rod **18** the swing lever **20** to drive secondary connecting rod **22** against slide yoke **24** and ram bushing **26**. This action drives or "pushes" ram **28** in the direction of arrow **30** through toolpack **100** and up against domer **32**.

The complete cycle of one revolution of the crankshaft **14** completes with return or "pull" of the ram **28** in the direction of arrow **31**. The cam follower mechanism timely returns the redraw carriage **34** connected to redraw push rod **36** and the hold-down lever **38** releasing the cup and opening for next cup placement. The crankshaft is similar that of a car engine (one piston) and cams operate the clamp mechanism to hold the cup. The punch/ram are moving at about 500 strokes per minute (about 26 inches) in each direction.

The draw and iron process includes loading the cup article into the redraw tooling **27**, clamping the cup, then the ram **28** forces a punch tool **25** through. During the forward stroke, the bottom of the cup is pushed on the punch **25** such that the side walls of the cup article are drawn or "stretched" as the ram **28** moves through the toolpack **100**, thus giving the cup an elongated shape of the formed can body **8**. Each stage of the tooling reduces the containers walls and elongates the container height correspondingly.

The can body **8** being formed is then "stripped" or released from the ram **28** via stripper **40** on the return stroke, and taken away by the unloader assembly **42**. Many machines are also equipped with high pressure air stripping assistance due to the high rates of speed to remove the container **8** from the punch **25**. This automatically discharges the formed containers **8** such that the next can body **8** may be formed.

Various ironing apparatus drive mechanism designs exist in the market as common art: examples are Hypocycloid gear drive, watts linkage drive and various parallel motion assemblies, etc. The consistency of the ironing apparatus **10** all use the 'toolpack' **100** to iron metal into various container shapes. The drive mechanism of the apparatus is only used for example and description of invention application, understanding various other drive mechanisms may be utilized with the invention of the metal forming toolpack **100**.

An entire cycle of the ironing apparatus (both the forward and return stroke) is completed in one continuous motion of 360 degrees crankshaft rotation at very high cyclic rates (e.g., between 150-500 cycles per minute (cpm)) producing a single container **8** per a complete single stroke. The toolpack **100** controls the deformation of the metal container wall between carbide tooling of the ironing die(s) **47** and the punch **25**. Typically, containers **8** require a redraw operation and multiple ironing operations to reduce the wall and elongate the container to the desired shape and specifications within a toolpack. The ram **28** is typically under ultra-high forming pressures, loads, velocities and thermal conditions as the frictional aspects of ironing increase significantly as production speeds increase forming velocities directly.

The friction of the tools and resultant thermal reactions of the metal ironing process often determines the quality of the resultant container that is produced. The ironing process reduces the container wall thicknesses of the starting material (e.g., the cup) by about 25%-75%, and elongates the container walls into the desired final container height and geometric shape. The desired tolerances of container walls are required within microns and normal variations desired of final wall thickness are within +/−0.00015" (7.6 microns).

Process variation adversely affects the quality of can body wall and finished can weight accuracy. Process variance increases as the thermal conditions vary due to production speeds and duration requirements of 24 hour a day production schedule requiring measured precision control and consistency to produce desired product accuracy. Process variance also increases as the die movement attenuation of ironing forces in axial, radial and/or lateral directions may become instable or degrade during the ironing process. Forming velocity has been traditionally limited by these conditions and interactions resulting in increased variance at high speeds above 350 units per minute.

The metal forming toolpack **100** disclosed herein may be utilized to improve the energy of dampening, speed of dampening and reduced variance of force attenuation during the ironing process. The production speed of the ironing apparatus is improved in combination with improved stability of the process variance over time, and this results in improved consistency of unit quality and lower wall variance of formed containers and preforms produced.

Before continuing, it should be noted that the example apparatus **10** described above is provided for purposes of illustration, and is not intended to be limiting. Other devices and/or device configurations may be utilized to carry out the operations described herein.

FIG. **2**A is a perspective view of an example toolpack **100** disclosed herein. FIG. **2**B is an exploded perspective view of the example toolpack modules of toolpack **100** shown in FIG. **2**A. In an example, toolpack **100** may be utilized to control the tooling arrangements required to produce beverage or food containers during the draw and iron process.

In an example, toolpack **100** may include one or more modules **44** and one or more spacer(s) **46**. The modules **44** house and integrate at high speed the ironing tooling(s) to iron and form the metal thickness of specific geometrically shaped metallic bodies. The spacers **46** simply dictates the length required between dies **47** of the ironing elongation changes of the process. It is noted that the toolpack **100** is not limited to any spec configuration and/or number of module(s) **44** and/or spacer(s) **46**.

FIG. **3** is an exploded perspective view of one example of the toolpack modules **44**. The toolpack modules may have various configurations, as described within reference FIG. **4** and FIG. **5** as demonstrated. However, each of the toolpack module **44** may include the general configuration of a module housing ring **50**, dampening structure **52**, die carrier **32**, and coolant nozzle **34**. FIG. **3** illustrates correspondence of the perspective view of the module **44** variations shown in FIG. **4** with the close-up partial (e.g., upper) cross-sectional views of the various modules **44** shown in FIG. **5**.

FIG. **4** shows cross-sectional views of various modules **44'** of the example toolpack modules shown in FIG. **3** of toolpack **100**. One or more of these modules **44'** may be implemented into a single toolpack **100'**. Any and all combinations of Dampening structures **52'** may be mounted in the tooling module housing ring **50'**. The die carriers **32'** may be mounted in the dampening structures **52'**. Ironing dies **47'** are mounted in the die carriers **32'**.

Individual toolpack modules **44"** may be configured to accept any size tooling **47'**. Current Industry standard is a six inch diameter by three-quarter inch wide carbide dies. There is no limitation of the design to incorporate other die **47** sizes of various diameters and thicknesses. The toolpack **100** of the dampening structure **52** accommodates various diameter changes via die carrier ring **32** as well ability to accommodate new configurations not shown by example.

The dampening structures **52***a-e'* includes a unified structural dampening design which centralizes articulation forces and attenuation of the ironing dies, thereby maximizing spring energy, die centralization and speed of attenuation response. The dampening structures **52***a-e* may include variations of structures molded from urethane or Viton (or other suitable material) for desired attenuation performance and long service life. The durometer of the dampening structure **52'** may vary for each die position, e.g., to improve die **47** attenuation of actual ironing forces ideal for that sequence. For example, a dampening attenuation force for a die **47***a* in the second ironing sequence operation in the toolpack **100** may be a higher attenuation force than the forces required for a die **47'** in the third sequence of ironing. These attenuation differences are mainly controlled by the metal formation physics of material reduction, friction, lubrication and tool geometries.

The dampening structures **52***a-e* may include an attenuation design with internal pressurization geometries that centralizes attenuation forces of the ironing dies **47***a-e* requirements of the metal formation process. The geometry of the dampening structures **52***a-e* may be configured to provide variable dampening rates of attenuation to accommodate various process changes. Numerous example geometries **56***a-e* are demonstrated internally within the dampening structures **52***a-e* for example only. These sample cross section for each of the modules **44***a-e* demonstrate innumerable geometric and material combination options to ideally create radial configurations that optimize ironing attenuation performance. It is clear that one or more of these various dampening attenuation structures may be implemented into a toolpack **100**.

The dampening structure **52'** may incorporate various internal geometric options **56'** of improved dampening attenuation forces through external excitation and communication. Internal connection enables internal pressure chambering **56** to change the media **52** dampening attenuation response. The variability of media attenuation improves tool **47** centering as well as speed of articulation of the integrated tooling **47** requirements.

The internal geometries **56'** may include various media, fluids, gases, gels or other pressuring systems. The media may also be intermixed or constructed integrally with various reinforcement materials and/or geometries **56'**. Examples include but are not limited to fibers, Kevlar™, steel cable, and/or various cording and/or energizing cabling construction types of attenuation reinforcement. These improved attenuation options may extend performance life of the dampening medium for millions of cycles to last through years of demanding production.

The dampening medium **52'** functions in unison of displacement attenuating the ironing tooling **47'** within the dampening structure **52***a-e*, also integrating the coolant distribution **34***a-e*

The coolant distribution nozzle **34***a-e* focuses the coolant impingement into the ironing area. The nozzle focus may maintain a stable thermal temperature during the ironing speed and reduce metal ironing during the manufacturing process of canmaking.

The speeds are typically as much as five hundred inches per second (or 45 ft/s). This equates to 30 miles per hour average forming velocity for each container produced. It is clear that these high rates of metal forming speed require complete and intimate control of the coolant and tool movements. The proper application and impingement of coolant is important to controlling the ironing temperature at these high rates of velocity. Excessive temperatures can cause a loss of material strength through localized tempering. Excessive temperature can result in product failure, jams, and/or defects being created that negatively impact product quality aspects. These high rates of forming speeds demand high precision to maintain optimal and stable metal forming temperatures.

The coolant channels **57***a-e* are incorporated within the die carriers **32***a-e*, as better viewed in FIG. **5**. FIG. **5** are detailed cross-sectional views of an upper portion of the various modules shown in FIG. **4**. Coolant may be provided via coolant channels **57***a-e* feeding the coolant nozzle **34***a-e*. This enables coolant delivery that can be optimized locationally focused into the ironing zone. The example embodiment uniquely incorporates the nozzle geometry to perfectly locate during any and all displacements of the dies **47***a-e* (e.g., as the die **47** moves or floats during the ironing process, the coolant moves in unison **34***a-e*). In an example, coolant delivery may be adjusted to optimize coolant delivery at the work area of the dies **47***a-e*.

FIG. **6** is a detailed cross-sectional view of typical arrangement of the modules of the example toolpack **100**. In this example, the modules are assembled into the toolpack **100** illustrated in FIG. 2A, including modules **44***e* and **44***d*, spacers **46***a-c*, and redraw module **48**. The toolpack **100** is illustrated of variably defined geometric structure and makeup of dampening structures (e.g., **52***e* and **52***d* are shown), combined with integrated die carrier rings (e.g., **32***e* and **32***d* are shown) and coolant structures (e.g., **34***e* and **34***d* are shown).

FIG. **7** is an end view of one of the example toolpack **100**. The die elements **47** of the toolpack **100** shown in FIG. **6** may be configured with coolant distribution by coolant nozzle rings **34**. These coolant distribution ports **57** feed nozzle **34** are not limited to fixed locational die **47** articulation changing impingement in all current art. This novel example, the articulation of coolant distribution **34** is focused in unison to track the tool position automatically in continuous displacement with die carrier **32**. The coolant nozzle **34** always moves wherever the die **47** moves. This improves the coolant contact impingement and the locational focus of the coolant impingement improves thermal consistency of the ironing zone(s). The coolant nozzle **34** and distribution automatically tracks, moves, and distributes coolant impingement to an infinite variance of tooling positions directly improving thermal stability and thermal efficiency of ironing geometric intensity. This enables improved metal forming production rates, container quality, tool life and reduced tool wear through the improved coolant impingement, geometrically optimized thermal stability and contiguous tool tracking resulting in thermally stable ironing processes at higher speeds.

In an example, the toolpack **100** may improve the centering and dampening response of the necessary tooling with vastly increased radial energy. The increased mass of dampening structure **52** improves speed and action of the tooling **47** such that improved tooling response articulation to product quality demands, increased throughput, improved manufacturing efficiency and direct process feedback is achieved. Ideal management of these high production speeds and the sheer volume of billions of annual units produced is vastly improved by the increased speed of force attenuation features and external excitation methods of the example invention.

The toolpack **100** may also enable integration of dampening energy adjustability and tool articulation through increased centering forces infinitely oriented structurally in a united and focused external excitation means. Managing these ironing responses requirements may be further automated through linked communication to the process and/or quality systems. The toolpack **100** may implement a complete axial and lateral force adjustment during the machine operation and cycling. Examples result in vast improvement of the production efficiency, throughput and quality of containers produced by the novel ability to adjust and/or optimize centering force response and dampening quickness of the toolpack **100**.

Existing art has been measured at 85%-92% efficient for best in class operations around the World. Those skilled in the art readily understand these efficiencies 85%-92% are best in class. It is a claim of this invention to support and enable significant improvement of efficiency and throughput by removing the manual requirements of process optimization. The manual intervention always results in a loss of production throughput. Maximum machine speeds are never exceeded or a catch-up speed is not viable due to the current limitation of production speeds are less than 400 cpm. Production is always lost each and every time the ironing machine is maintained for any adjustment to the process. The external excitation means and communication with the process variance is critical to achieving higher efficiencies and therefore producing vast gains in produced annual units via the apparatus speed up to 400 cpm, running 24 hrs/day, +360 days per year. Any time (even a minute) that the machine has to be shut down is a major loss in productivity. That lost production cannot be made up.

The toolpack **100** may further provide a novel application of integrated coolant distribution with specifically optimized locational displacement tracking, movement unification and directly calibrated communication of variable tooling positions upon novel integration of die carrier **54** and coolant distribution structure.

The toolpack **100** further provides improved dampening speed of axial and longitudinal articulation obligations of the tool ironing process displacements and attenuation variance through increased force mass structure combined with explicit geometric medium construction of dampening structure **52**.

The toolpack **100** further provides full axial conformity of greater quickness and force range by integrating completely encompassing directional articulation, responsively reducing tooling wear and improving tool life and performance of the congruent dampening structure **52**.

The metal is normally sized through various stages or sequences of tooling or die(s). These normally include at least a single redrawing stage, directly followed by subsequent ironing sequence(s). The ironing process requirement are determined by the desired thickness and shape of the container required thinning the metal and elongating geometric shape limits of the material.

The speed at which these articles may be manufactured is often limited by the inherent inability to adjust or adapt forces of the tooling with intelligence to the process requirements readily or by demand. Lack of dampening or speed of reaction often results in excessive thickness variation which requires operator intervention and/or downtime of the apparatus to remedy. Metal forming velocity and manufacturing efficiency rates are degraded by frequency of created defects, which can stop, fault, or altogether shut down the apparatus **1**, requiring operator intervention to restart.

The ironing process utilizes a toolpack **100** which incorporates and houses fixed and/or moveable die element(s). Multiple die elements are comprised of a steel casing and tungsten carbide or ceramic elements of standard geometric configurations utilized to form geometrically shaped metallic bodies. Due to the rapid cycling rate requirements, as much as 150-500 cycles per minute the dampening and vibration frequencies have been normally attenuated by a plurality of various fixed force rate biasing springs. The mechanical springs have been commonly used for many years and recent improvements have converted these springs to polymeric or urethane type spring configurations. However, these configurations lack any sort of force adjustment or attenuation adaption based upon production speed fluctuations, or variation of force requirements due to various process changes, or the optimization ability within process variables, such as material type, material coatings, friction, die type, lubrication, articulation, and/or formation velocities.

The toolpack **100** implements a dynamic centering force attenuation adjustability and intelligence which corrects limitations of die element dampening resulting from increased speed of attenuation induced by elevated ironing forces and process requirements induced from higher cyclic rates and reduced variation necessity. The novel dampening structure **52** may be implemented to adjust intensity of the dampening to improve the reaction speed of the tool to the workpiece through the optimization of force attenuation and energy focus with process intelligence (described in more detail below with reference to FIG. **8**).

The variable intensity of dampening attenuation structure may be implemented as a unitary circumferential integration of a contiguous structure or structured geometrically involving full force range optimization. The dampening structure (or structures) **52** incorporated within the modules **44** have a substantially increased biasing mass to create an improved force intensity attenuation and dampening speed. In an example, the dampening structure **52** can be a fully adjustable and attenuated energy dampening structure by material construction as well combined with various geometric options, such as those shown as geometric profile options **56**.

The toolpack **100** enables dampening intensity in a plurality of combinations of force attenuation(s) and orientation combinations of ideal fitment to the service requirement of the ironing and metal forming process of the metallic geometrically shaped bodies. The dampening structure medium **52** incorporates various combinations of geometric configuration, material variance, construction options in combination with external excitation (e.g., via communication component described below with reference to FIG. **8**), produces countless options of design specificity to the metal formation process needs. The toolpack **100** also enables a plurality of options and various combinations, formulations of fitment within the biasing medium structure **52** to optimize the dampening response intensity profile via specific orientation, optional geometric profiles or construction within the machine axis of orientation. These variations enable the toolpack **100** to be optimized for the dampening force intensity needs and requirements of specific ideal radial orientations to the machine and metal forming orientation needs.

The toolpack **100** incorporates the novel configuration of the biasing medium **52** to include numerous geometric options of orientation such that regionalized force intensity profiles may be intelligently configured for various geometric shapes or process requirements. The novel ability to combine external force attenuation with geometric configuration creates a plurality of pattern combinations ideally suited for the interactive intelligent response of the metallic body formation process. The combined ability to enhance, arrange and patterning of the geometric variables **56** of the dampening structure **52** in combination with force attenuation is a unique and novel claim of this invention.

The toolpack **100** provides complete ability to optimize the cylindrical forces through varied regions of attenuation intelligence, such that accuracy of the roundness of the metallic cylinder formation and the thickness variation of the metallic cylinder walls is optimized. The structure of the biasing medium for dampening structure **52** enables various inputs of energy that may be ideally located to specific quadrants, regions or orientation of the specific metallic body requirements. This enables the invention to improve the dampening forces in various regions or alter various other regions to optimize the metal forming processes. The toolpack **100** improves metallic formation capability and quality regardless of geometric configuration of the metallic bodies.

The toolpack **100** directly improves attenuation of the die element **47** speed of movement and reaction to the process by the increased mass of the radial biasing medium structure of the dampening geometry **52** in complete radial integration of the entire circumferential configuration of the dies **47**. The toolpack **100** embodies directly the increased biasing mass and volume of the resilient medium of dampening structure **52** being congruent and equally biasing response through the entirety of the radial geometry improving the speed of response demands and quickness of dampening. This improves the metal formation process as the die (tool) **47** maintains more consistent contact of the tooling and metal through the full and directional displacement communication with workpiece and tooling surfaces through a geometric balance of attenuated ironing forces.

The toolpack **100** specially provides increased structural configuration of energy of mass and dampening force attenuation with distinct equalizing axial communication through intelligent lateral dampening force control throughout the entire sequence of the ironing process actions. The toolpack **100** enables the integral dampening structure **52** of increased dampening means through the increased cross sectional mass energy in combined internal excitation means of completeness in biasment structure orientation options around the entirety of the geometric configuration of the toolpack module and die tooling **47** directly improving manufacturability, product quality, production speed and process capabilities.

The toolpack **100** also includes the integration of a complete radial centering medium of significant design variation, pattern configuration **56** and construction such that the ironing die elements (tools) **47** may be quickly and repeatedly centered to a 'home' position with greater accuracy and speed. The dampening structure **52** includes biasment options in a plurality of internal geometric arrangements and configurations, resulting in significantly improved quickness of tool **47** action and intelligent response to the process requirements resulting in optimized ironing forces. In an example, the toolpack **100** improves the die **47** attenuation and centering response to maintain a centralized or 'home' position such that production and manufacturing speeds, quality and throughput are greatly enhanced over prior art. This novel embodiment combines the unified compliant medium structure **52** with options in a plurality of integrated geometric shapes **56**, structures and as well materials. The toolpack **100** enables infinite options of centering and biasing force intensities that may be ideally enhanced by construction, material combinations and internal geometric applications chambering **56** when combined with the ability to be externally attenuated **62** and/or excited dampening or systematic force response intelligently **64**.

The toolpack **100** may further provide complete circumferential dampening force adjustability of definitive force intensity required of the ironing forces through novel combination of dampening structure **52** and a communication control unit **60**, discussed in more detail below with reference to the communication **60** and control system **64** of FIG. **8**. In an example, the toolpack **100** may responsively augment the force and quickness of dampening feedback directly automating and optimizing the metal forming processes to the ideal requirements of ironing through novel combination of the dampening structure **52** attenuation, excitation and the communication control unit **62**. In an example, the toolpack **100** may provide novel configurations of communication to the manufacturing process **200** such that the system of manufacture may now become configured for autonomous control and management resulting in significantly reduced labor, improved quality and higher production throughput. The toolpack **100** yields a novel ability to increase speed capability, while providing a distinct ability to adapt and adjust the communication intelligently **200** on demand to coordinate optimal force responses resulting in much lower variation at much higher production rates and metal forming velocities. This vastly improves manufacturing efficiency and apparatus production throughput.

FIG. **8** is a high-level block diagram illustrating communication **64** and feedback **60** which may be implemented for the example toolpack **100** via a communication and control system **62**. The communication and control system **200** may include a communications component **60** operable to self-adjust and modulate **62** associated with the toolpack **100** (see, e.g., FIG. **7**) of the can forming apparatus **10**, and a controller or processor **64**. In an example, a user or operator **1** may interact with the communication **60** and control system **200** via a control and adjustment interface **62**. In another example, the control and adjustment interface **62** may be entirely automated and/or simply monitored by operator **1**.

In an example, a tooling communication and control system **200** may be provided for the toolpack **100**. The communication and control system **200** enables adjustment of the dampening force intensity **62**. In an example, the communication component **60** controls, senses and adjusts the toolpack **100** biasment due to process requirements through external excitation methods. This communication also enables intelligent feedback through direct sensing and interaction during the metal forming process so that the tooling forces can be optimized without disassembly or intervention in the apparatus **100**, reducing or altogether eliminating machine **10** stoppage and associated loss of production. The communications component **60** also enables logical management of a specific intensity of required attenuation forces for ironing in a controlled methodical and scientific manner to dampen, excite and optimize the variable movements of the die elements **47** during the ironing process, being comprehensively optimizable, adjustable through external excitement **62**, with distinct interactive specific commands issued to the tooling. The communications, sensing and control component **60** also enables optimization via unskilled operator **1** to use simple adjustments 'on the fly', to change, correct and optimize the intensity of the metal formation forces with diverse and directional correlation via intelligent control communications **60**.

The adjustability of the toolpack **100** enables the enhancement and correlation of the management of process inputs to optimize performance within the complexity of the numerous random process variables of material alloy or type, material thickness, speed of machine cycle rates, increasing metal forming velocities and a plurality of process induced input variations which may now be directly sensed, correlated and intelligently **64** managed to specific set points or measurements. These readings, set-points and adjustments can be predictable from various other process combinations, data mining such that they become programmed **200** into the production requirements of specific configurations or ideal product needs. This enables production planning, and process optimization for various container sizes, requirements and variable process needs to improve overall size change, labor requirements, production efficiencies and unit output. These embodiments enhance this novel simplification of intelligent process adjustment **200**, scientific optimization and manageable regulation of the ironing process. This unique ability to sense, adjust, enhance and change the toolpack **100** system demands enables the operator **1** to intelligently optimize the intensity of dampening forces of the die elements **47** centering, attenuation and reaction speed for each application such that the improved quality, increased speed of production, ramp up slope and the net efficiency of manufacture of metallic bodies **8** is systematically enhanced through managed scientific optimization of the metal forming process.

The communication component **60** significantly improves the manufacturing production speed, efficiency and quality of the metallic cylinders by interactively attenuating the dampening force intensity profile of the unique dampening structure medium **52**. The communication component **60** provides the ability to optimize the external management of tooling response with process feedback and sensing of the ironing and metal formation tooling interactions directly enabling attenuation adjustment automatically or by operators and technicians to increase machine speed, cycle rates and quality of containers produced.

Container weight(s) or management of the weight of the metallic body is measured with high frequency to control scrap weight and saleable container weight resulting in overall material usage efficiency. The system provides process feedback of weight variance via the communication component **60**, and the ability to sense and externally adjust the force excitation of the tool within the metal forming process, may improve the management capabilities of production parameters **200**. The production control is critical to success as the volume of units is 500/minute which is: 30,000 units per hour, 720,000 units per day, equaling 260 million units per year, for each machine **10**. Management of these process variables may improve the quality of the containers produced as well as reduce the tool wear, tool usage requirements and material consumption rates. Highly intelligent container weight control process management systems **200** may be implemented to control the metallic material consumption and final product material volumes with ultra-high precision and consistency over the entire production population of billions of units **8**.

The communication and control component **60** also provides the ability to sense and communicate dampening, centering force intensity through a plurality of pressurization means and mechanisms arrangements of the attenuation and dampening structure **52**. External excitation in combination with sensing and complete geometric options of material structure **56** magnifies the arrangement intelligence of combinations and capabilities **62** with unique and novel communication control of the metal forming process **64**. This example further facilitates automation development **200** of the ironing and metal forming process such that instrumentation and sensing capabilities of the toolpack modules **44** may continue to be developed and intelligently simplified.

In an example, the communication component **60** may also enable instrumentation via MEMS or micro sensors, temperature, force, vibration, Bluetooth' or related pressure sensing devices and articulation feedback of the modules **44'**. As such, the process automation with direct measurement, feedback and process controls **60** of ideal configuration can be harmonized and linked by the production management systems **64**. An example may include the contiguous dampening medium structure **52'** of various geometric chambering patterns **56'** or shapes combined with various excitation materials to enable a simplified measurement, sensing and response system. Various geometric pockets **56** and/or pressure or displacement sensing feedback regions may be placed to ideally communicate the attenuation requirements of the process intelligently. The integrated medium structure **52** of dampening medium may also provide distinct attenuation and precise process feedback, various measurements and communication with manufacturing system automated controls **200**.

The ability to self-monitor, sense and measure system responses can be linked directly to the self-adjustability through automated pressure valve(s) or force attenuation systems which directly adjust and vary changes of attenuating forces or dampening response of the dies **47**. Alternatively, the pressure mediums of dampening structure **52** attenuation may be a plurality of sources, such as hydraulic, magnetic or other readily available force mechanisms to modulated tool position and dampening attenuation of the dies **47** based upon correlated communication feedback with statistical process control measurements of can bodies **8** and a plurality of various other process measurements of the production or quality systems. Corresponding force attenuation via quadratic relationship or regional geometrically specific sensing and/or excitation may be directly altered automatically in force intensity or attenuation demands directly improving the variance and performance of the metal formation processes.

In an example, the communication component **60** can directly communicate with statistical process control (SPC) systems and/or automated manufacturing systems interlinking the ability to sense, attenuate, adjust, monitor and/or optimize the dampening intensity demands directly reducing manning and labor requirements of the prior art processes. Recording various manufacturing metrics of the ironing process over production intervals of time enables intelligence of process never before created by existing art. This permits the automation of manufacturing management processes to dynamically communicate and/or measure each toolpack module, to each individual die element, each container produced or any various combinations of lines or machine(s), apparatus throughout the entirety of the container manufacturing system.

It will be understood by those having ordinary skill in the art after becoming familiar with the teachings herein that the toolpack **100** and the communication component **60**, provide a competitive advantage to create a self-autonomous manufacturing system(s) of the metal forming and ironing processes. The variable geometric configurations of the continuous geometric biasment structures **52** and combination of patterns throughout the entirety of the container shape provide a creative ability of attenuating forces, dampening externally, sensing feedback without complexity and high cost of construction—while maximizing process capability, intelligence and economic value of options to easily manipulate benefits of production speeds and container quality without stoppage of the machine. The examples described herein provide direct claim to increase unit production, unit quality and net output while reducing manning and labor requirements over a lower unit cost basis through higher production speeds and improved product quality.

It is noted that the examples shown and described are provided for purposes of illustration and are not intended to be limiting. Still other examples are also shown and contemplated.

The invention claimed is:

1. A toolpack for manufacturing containers, the toolpack having a plurality of individual modules and a control system, each module comprising:

a module ring;

a dampening structure within the module ring, the dampening structure comprising a contiguous dampening mechanism comprising at least one pressurized chamber;

a die carrier and an ironing die within the dampening structure;

a coolant structure integrated within the die carrier; and

one or more sensors configured to produce a signal indicative of a parameter;

wherein the control system is coupled with the dampening structure, and wherein the control system is configured to receive the signal from the one or more sensors and adjust the at least one pressurized chamber based on the signal.

2. The toolpack of claim **1**, wherein the adjustment of the at least one pressurized chamber is configured to centralize articulation forces and attenuation of the ironing die.

3. The toolpack of claim **1**, wherein the dampening structure is performs radial articulation and lateral force intensity attenuation through adjustment of the at least one pressurized chamber.

4. The toolpack of claim **1**, wherein adjustment of the at least one pressurized chamber provides adjustable force intensity attenuation.

5. The toolpack of claim **1**, wherein the dampening structure provides an axial and lateral dampening force.

6. The toolpack of claim **1**, wherein the at least one pressurized chamber comprises a plurality of various geometric chambers in geometric configurations selected based on a desired force intensity, attenuation and service longevity of the dampening structure.

7. The toolpack of claim **1**, wherein the at least one pressurized chamber further comprises a plurality of geometric chambers located at different locations around or within the contiguous dampening mechanism.

8. The toolpack of claim **1**, wherein the contiguous dampening mechanism is actively energized.

9. The toolpack of claim **1**, wherein the contiguous dampening mechanism is passively energized.

10. The toolpack of claim **1**, wherein the parameter is one or more of pressure, location, temperature, or vibration.

11. The toolpack of claim **1**, wherein the at least one pressurized chamber is adjustable by fluid, gels, or electrical/magnetic excitation based on the signal from the one or more sensors.

12. The toolpack of claim **1**, wherein the adjustment of the at least one pressurized chamber produces responsive articulation in both a radial axis and a lateral axis.

13. The toolpack of claim **1**, wherein the control system is further configured to adjust the coolant structure based on movement of the ironing die.

14. The toolpack of claim **1**, wherein the control system is configured to adjust the at least one pressurized chamber within the contiguous dampening mechanism on the basis of a desired product quality being produced by the toolpack.

15. The toolpack of claim **1**, wherein the control system is configured to receive external sensor readings from the die carrier including monitoring of tool positional energy, intensity and speed of dampening response mechanics.

16. The toolpack of claim **1**, wherein the contiguous dampening mechanism is a molded structure.

17. The tool pack of claim **16**, wherein the molded structure comprises urethane or Viton.

18. A toolpack for manufacturing containers, the toolpack having a module comprising:

a module ring;

a dampening structure within the module ring, the dampening structure comprising a contiguous dampening mechanism comprising a plurality of pressurized chambers;

a die carrier and an ironing die within the dampening structure, wherein the contiguous dampening mechanism surrounds the die carrier;

one or more sensors configured to produce a signal indicative of a parameter; and

a control system coupled with the dampening structure, wherein the control system is configured to receive the signal from the one or more sensors and adjust the pressurized chambers based on the signal to provide variable dampening rates.

19. The toolpack of claim **18**, further comprising a coolant structure comprising a coolant nozzle configured to move in unison with the ironing die.

20. The toolpack of claim **18**, wherein the plurality of pressurized chambers are spaced from each other and have different shapes to provide regionalized force intensity profiles in relation to a Cartesian orientation within the toolpack.

* * * * *